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Contract NAS10-8676

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LAUNCH SITE PROCESSING OF HAZARDOUS PAYLOADS

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FINAL REPORT

VOLUME 2

HAZARDOUS PAYLOAD SURVEY AND ANALYSIS

LAUNCH SITE PROCESSING OF HAZARDOUS PAYLOADS

MAY 1975

Contract NAS10-8676

APPROVED BY:

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FOREWORD

This document constitutes Volume 2 of a seven-volume Final Report prepared by Teledyne Brown Engineering, Huntsville, Alabama, under NASA Contract No. NAS10-8676, Launch Site Processing of Hazardous Payloads. This study required a thorough analysis of the impact on the launch site and its operations by hazardous Space Shuttle payloads.

The seven volumes of the Final Report are as follows:

Volume 1. EXECUTIVE SUMMARY: This volume presents a concise review of the results of the study tasks and summarizes the principal conclusions and recommendations of the study.

Volume 2. HAZARDOUS PAYLOADS SURVEY AND ANALYSIS: This volume presents the results of a survey and analysis of proposed Shuttle payloads to identify hazardous payloads and define the characteristics of materials and systems which make them hazardous. This task included the development of a hazardous payloads ranking technique and recommendations for processing analysis on selected payloads.

Volume 3. NORMAL PROCESSING ANALYSIS: This volume presents preliminary normal processing flow plans for three Shuttle cargoes selected as a result of the Hazardous Payloads Survey and Analysis Task. These three cargoes are:

- Spacelab with Advanced Technology Laboratory
- Tug, Solar Electric Propulsion Stage, and Synchronous Earth Observatory Satellite
- Interim Upper Stage and a Pioneer Jupiter Probe with a Fluorine Propulsion Unit

The preliminary processing flow plans include identification of unique facilities and GSE, processing hazards, and payload safety related design criteria.

Volume 4. CONTINGENCY PROCESSING ANALYSIS: This volume presents preliminary alternate processing flow plans for contingency situations for the three Shuttle cargoes analyzed in the Normal Processing Analysis Task.

Volume 5. CURRENT PAYLOADS SURVEY AND ANALYSIS: This volume presents the results of a survey and analysis to determine payloads that are currently flying and that may also fly on the Shuttle vehicle when it becomes operational. The analysis determines hazardous materials/systems for each of these current payloads and recommends design and operational safety criteria for each hazardous current payload to minimize its impact on the Shuttle Transportation System.

Volume 6. ENVIRONMENTAL IMPACT STATEMENT POTENTIAL REQUIREMENTS: This volume presents the results of an evaluation of the probable environmental impact of Shuttle payloads hazardous materials and includes recommended KSC Environmental Impact Statement Potential Requirements.

Volume 7. ADVANCED TECHNOLOGY REQUIREMENTS: This volume presents a list of special problems identified in the study which require advanced technology study or technology development.

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1.0 INTRODUCTION

Payloads containing hazardous materials associated with space vehicle launch operations have been recognized and dealt with on previous R&D space programs. However, when compared to the Shuttle Program, these R&D space programs involved relatively few launches with considerable time between launches. The Shuttle operational program will have a high launch rate and in many cases individual launches will have several independent payloads for accomplishment of separate missions. Some of these payloads by intent will be recoverable for purpose of reuse, and all must be recoverable in the sense that possible abort situations prior to deployment have to be recognized.

Safety oriented studies on Shuttle payloads have been performed in recent years. However, relatively few of these have treated ground operations in depth, and the overall impact of Shuttle payload hazards on launch and landing site processing and procedures has not been documented. In order to fill this gap, this study was initiated in July 1974. The overall study objectives were to determine the hazard potential of Shuttle payloads, develop safety oriented normal and contingency launch site processing plans for selected cargoes that will minimize the impact on cost and schedules, and provide for environmental protection.

1.1 TASK OBJECTIVES

The purpose of this hazardous payloads survey and analysis task was to determine which payloads were candidates for the Space Transportation System (STS), to identify those payloads that contained hazardous materials or systems, and to ascertain those characteristics which make them hazardous. This task also included the development of a hazardous payloads ranking technique to assess the hazard potential of the payloads and to assist in the selection of hazardous Shuttle cargoes, consisting of several representative payloads each, for the principal tasks of this study, namely, the analyses of normal and contingency processing of hazardous payloads.

1.2 SCOPE

The hazardous payload survey and analysis task considered all non-Department of Defense (DOD) payloads currently scheduled, as well as some that may later be scheduled for flight.

1.3 TASK APPROACH

The approach to this task was to conduct an extensive documentation search and to contact the scientific community to identify those payloads that include potentially hazardous materials/systems. An analytical technique was developed for analysis for these payloads whereby an objective engineering judgment of the hazard potential of each payload could be established as a function of the severity of the impact on Shuttle operations and the likelihood of its developing into an unplanned event or accident. A listing of all Shuttle hazardous payloads by category and a detailed description of the characteristics of the hazardous materials/systems were generated.

Candidate cargoes were developed using the 727 cargoes in the Shuttle traffic model as well as those scheduled for the first 20 missions. Also, tentative cargoes comprising different payload groupings that could be flown were developed and tested for compatibility, taking into account orbital requirements, size, weight, etc., as an aid in selecting feasible candidate cargoes. A second series of tests utilizing a cargo selection rationale consisting of hazard potential, hazardous materials and quantities, systems coverage, unique materials and processes, and number of flights was used to obtain a manageable number of cargoes that would be representative of the payload hazardous categories. The rationale for the final selection of cargoes to be analyzed in the normal and contingency processing analysis included high hazard potential, high number of flights, broad spectrum of hazardous materials, and a payloads processing scenario to ensure that all major launch site processing paths would be covered. Application of the above philosophy resulted in selection of the three most representative cargoes for normal and contingency processing analysis from a candidate cargo group of 14. A schematic outline of this payload assessment and cargo selection process is presented in Figure 1.

1.4 SUMMARY OF RESULTS

1.4.1 Payloads Survey

A comprehensive documentation search and review and communications with NASA and the scientific community were used in the survey and identification of the various Shuttle payloads for hazardous materials/systems. This payloads survey identified 220 potentially hazardous payloads that may fly on the Shuttle vehicle when it becomes operational.

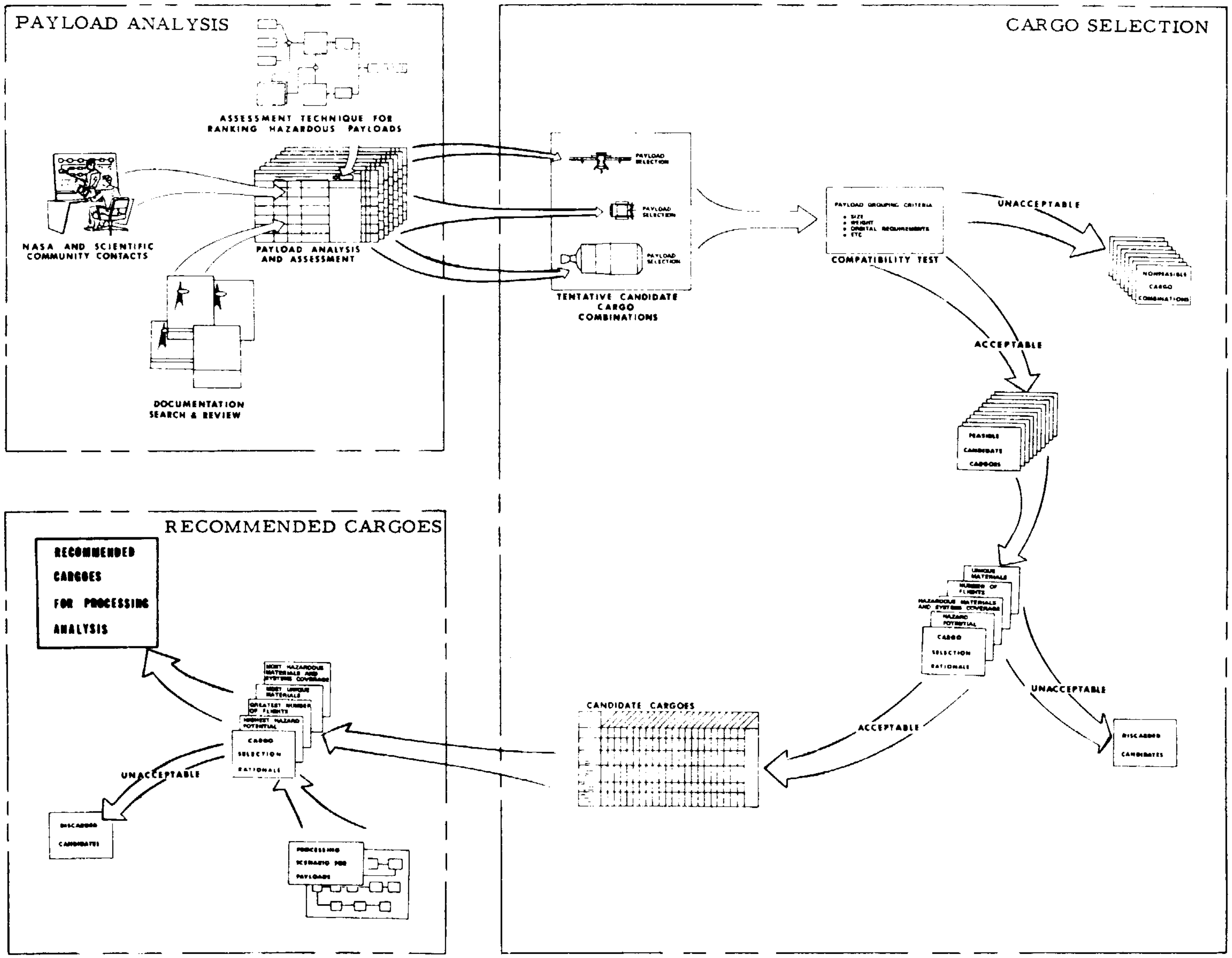


FIGURE 1. **HAZARDOUS PAYLOAD ASSESSMENT AND CARGO SELECTION PROCESSES**

1.4.2 Hazardous Materials/Categories

Types of materials and systems hazardous included in each hazardous category which were found in Shuttle payloads were:

TABLE I. HAZARDOUS MATERIALS/SYSTEMS SUMMARY

Category	Hazardous Characteristics	Hazardous Materials/Systems
Cryogenics	Asphyxiants, explosive, flammable, contamination sensitive, toxic, personnel injury/equipment damage from extreme cold.	LH_2, LO_2, LHe, LHeII, LNe, LN_2 and LF_2
Hypergolics	Flammable, corrosive, toxic, contamination sensitive, explosive.	Hydrazine and its methyl derivatives, nitrogen tetroxide, fluorine, and Inhibited Red Fuming Nitric Acid (IRFNA).
Toxic/Asphyxiant	May act as asphyxiants by displacing air and/or vapor may be toxic.	Ammonia; gaseous argon, helium, neon, krypton, xenon, nitrogen; Freon 113 and related chlorofluoro compounds; mercury; silicate esters (cooling fluid).
Radiological	Burns, injury, equipment damage, high temperature.	RTG's, RHU's, laser, UV, microwave, RF, barium, americium, X-ray, ion source.
High Temperature	Burns, ignition source.	Heaters, RTG's, RHU's
High Pressure	Injury, damage, explosive.	-
Electrical	Shock, sparking, overheating, burns, ignition source.	-
Microbiological	Pathogenic hazards.	Microorganisms, bacteria, viruses.
Fire/Explosives	Flammable, explosive, sensitive to RF, spontaneous ignition in air.	Solid propellants; pyrotechnics, batteries, methane and homologous hydrocarbons; and flammable metals such as rubidium, cesium, and lithium hydride.

1.4.3 Assessment Technique

To rank the various payloads as to their potential ability to cause an undesired or unplanned event or accident, all payloads were analyzed and assessed as to their hazard potential. The hazard potential is a function of the likelihood of occurrence of an undesired event and of the impact of such an occurrence.

1.4.4 Selection of Cargoes

Representative cargoes for the processing task analysis consisted of assembling a number of tentative candidate cargoes and subjecting each one to a series of screening operations. Each of the tentative cargoes was analyzed to ensure that size and weight did not exceed the capability of the Orbiter and then tested for orbital and mission compatibility. The cargoes were then examined for unique materials and processes and for the estimated number of flights.

1.4.5 Final Cargo Selection

The following three Shuttle cargoes consisting of nine payloads were selected and approved by KSC for processing analysis in this study.

- A Spacelab with an Advanced Technology Laboraory (ATL) and an Integrated Real Time Contamination Monitor (IRTCM).

- A cryogenic fueled Tug with a Solar Electric Propulsion Stage (SEPS) and a Synchronous Earth Observatory Satellite (SEOS). The SEPS is a mercury fueled kick stage with a mercury-ion propulsion system.

- A conceptual Interim Upper Stage (IUS), and a Pioneer Jupiter Probe (PJP) with a Fluorine Propulsion Unit (F_2PU) The IUS is fueled with hypergolics; the fluorine propulsion unit was selected primarily because of the renewed interest in fluorine as a propellant; and the PJP is of major interest because it contains Radioisotope Thermoelectric Generators (RTG's).

2.0 PAYLOADS SURVEY AND HAZARDOUS CHARACTERISTICS

2.1 PAYLOAD SURVEY

This phase of the task resulted in an assessment of all potential Shuttle payloads. This was achieved through a comprehensive documentation search and review and through communication with NASA and the scientific community.

2.1.1 Documentation Search and Review

The primary purpose of the documentation search and review was to identify potential payloads for Shuttle flights and advanced missions. Many of the documents reviewed did not specifically address potential payloads but were useful as guides in the analysis and identification of hazardous materials of potential payloads.

The documentation search revealed approximately 220 potentially hazardous payloads for Shuttle flights. The main sources of payload information were the Space Shuttle Payload Descriptions (SSPD's) prepared for the Marshall Space Flight Center (MSFC). The documentation review considered all payload (except those of the DOD) as being candidates for launch by the Shuttle. Various payloads, such as radioactive waste and biological material, in addition to those specified in the MSFC and European payload description documents, were considered.

2.1.2 NASA and Scientific Community Contacts

In defining payloads and establishing the potential hazards associated with each, it was necessary to establish a wide range of contacts to collect data. Existing mechanisms within the MSFC Payloads Studies Offices were used in addition to direct contact with persons within the scientific community (Figure 2). In areas where more details than contained in the SSPD documents were required, appropriate MSFC personnel were contacted and this information was requested. In other areas, experimenters involved in previous programs were contacted to determine their interest in using the STS.

Major NASA centers and NASA Headquarters offices were contacted to keep abreast of current philosophies and planning. These efforts have greatly enhanced the insight into the STS and its utilization and provided sufficient additional information to determine which payloads may present the greatest impact to the launch site.

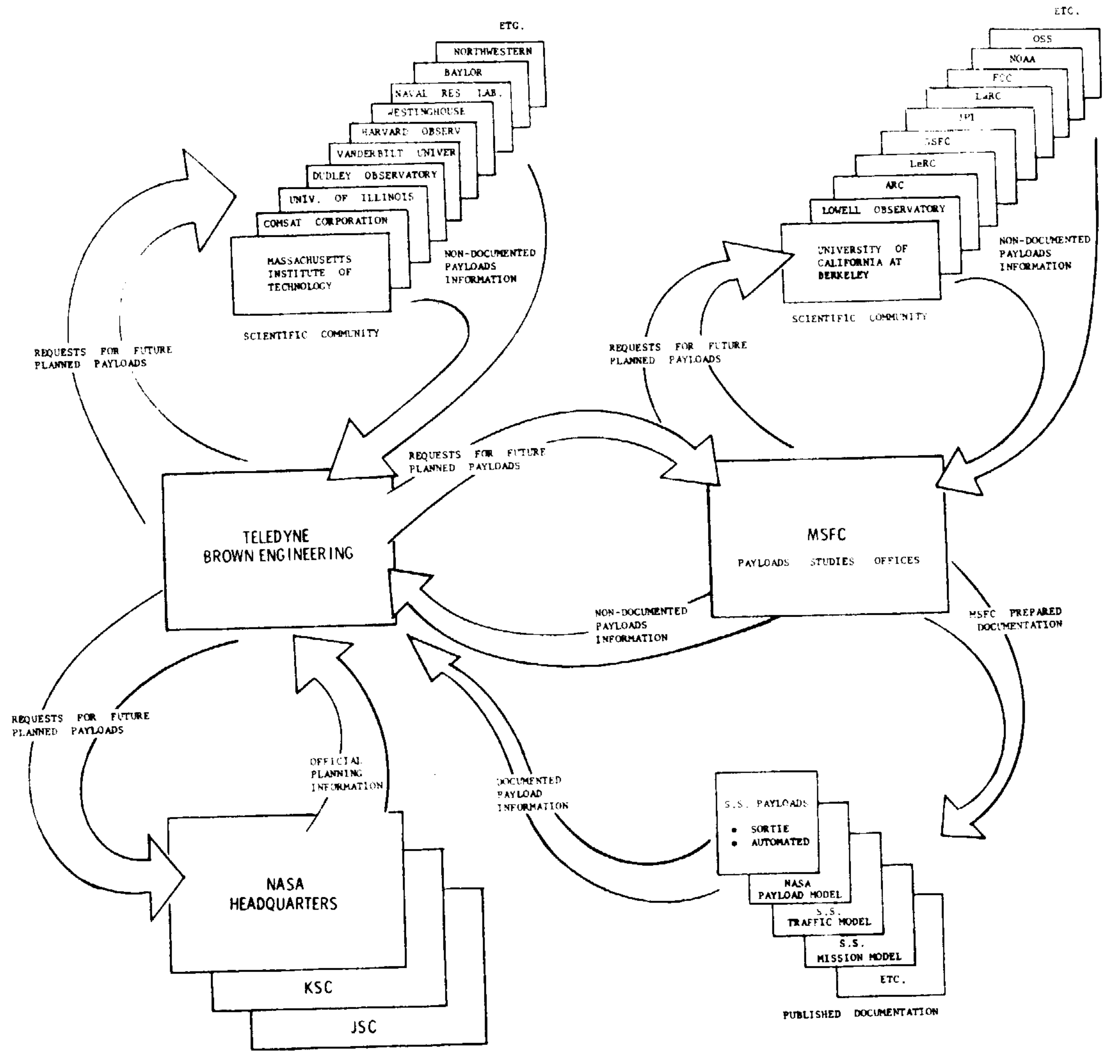


FIGURE 2. PAYLOADS INFORMATION SOURCES

2.1.3 Survey Results

The results of the Shuttle payloads survey and analysis task are shown in Figure 3. This summary chart shows all hazards identified for the payloads surveyed in this study. The hazards presented in each payload are indicated in the matrix tables. Also shown are the scheduled number of launches for each payload and our estimate of the hazard ranking factor or "hazard potential".

The principal sources of these data are as follows:

- SSPD Volume I, Level A, July 1974
- SSPD Volume I, Level B, July 1974
- SSPD Volume II, Level A, June 1974
- SSPD Volume II, Level B, July 1974
- ESRO Level A, Spacelab Payload Data Sheets, February 1974
- Volume III Payload Descriptions, ESRO, Level B (Preliminary Issue)
- MSFC Baseline Tug Definition Study Reports, 1974
- Spacelab Payloads Accommodation Handbook, October 1974

Also, numerous other reports of studies on special payloads and contact with payload developers were used to supplement the primary data sources.

2.1.4 Launch Site Hazard Frequency by Payload and Occurrence

Of particular interest to facilities planning for Shuttle payloads which have unique hazardous materials or special problems is the total number of launches or total exposure of the launch site to a unique hazard or processing operation. Although a particular hazardous system may require special facilities, GSE, and handling, it may not be cost effective to provide permanent facilities dedicated to handling a very hazardous payload with only a few applications. Special plans or work-arounds may be the most cost effective method to provide the necessary safety levels. Alternately, a hazardous system with a high number of

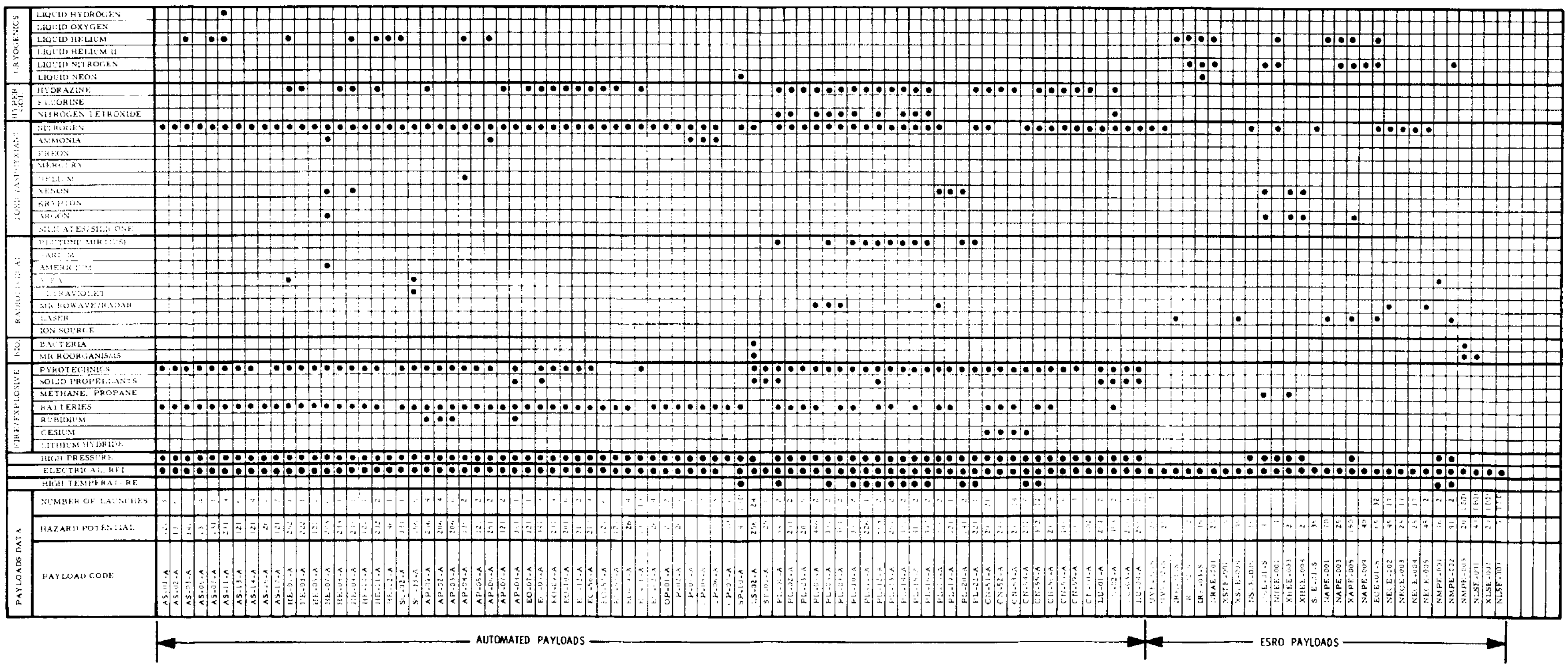


FIGURE 3. SHUTTLE PAYLOADS HAZARDOUS MATERIALS/SYSTEMS (Sheet 1 of 2)

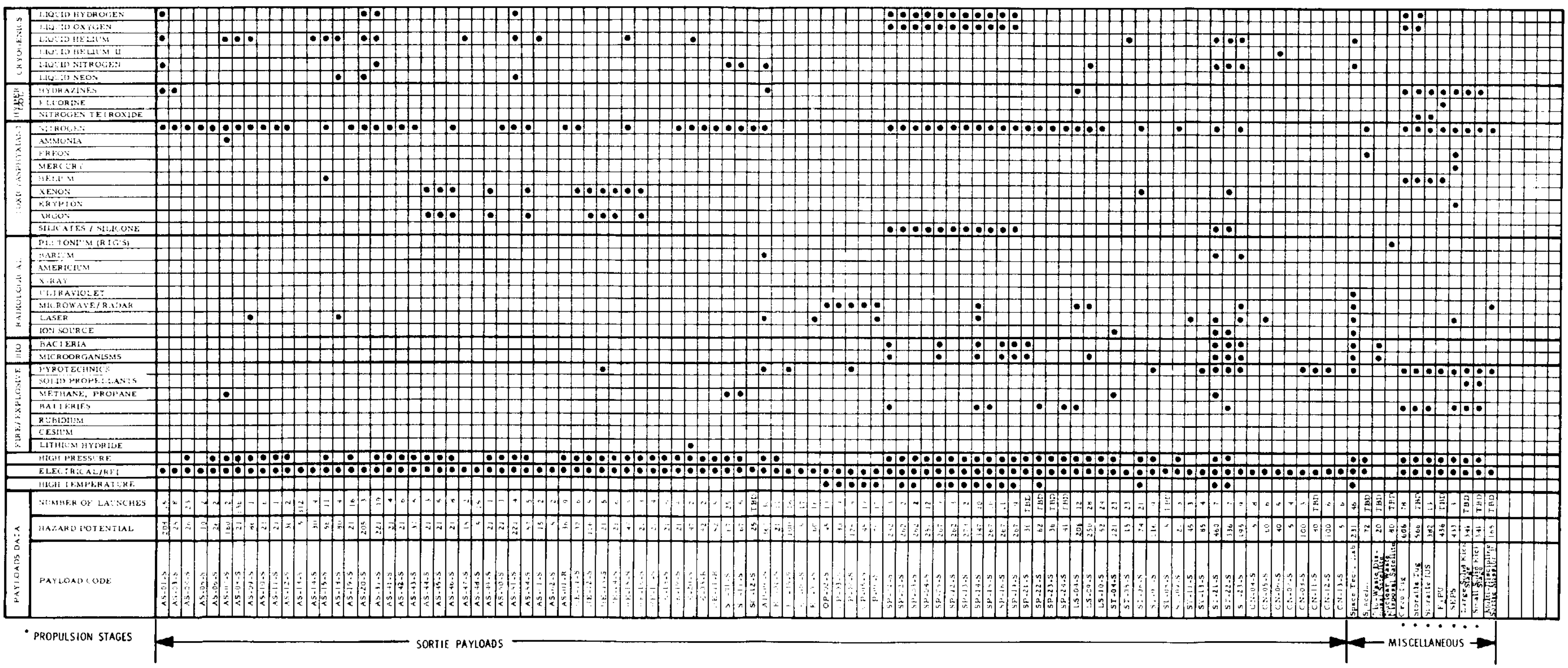


FIGURE 3. SHUTTLE PAYLOADS HAZARDOUS MATERIALS/SYSTEMS (Sheet 2 of 2)

applications and launches and a high launch rate may be more effectively processed from safety, time, and cost considerations in a permanent, dedicated on-site facility.

Figures 4 and 5 summarize the frequency of occurrence of hazards by payload only and the frequency of occurrence of hazards considering the number of launches of all payloads. The payload hazards are shown in descending order of occurrence.

2.2 HAZARDOUS MATERIALS/CATEGORIES

A review of the Shuttle hazardous payloads has delineated a number of hazardous materials and/or conditions that may be encountered during processing at KSC. A description of the characteristic chemical, physical, physiological and related hazardous properties of the various categories of hazard sources have been assembled in Appendix A. These descriptive summaries are intended to provide background and insight into the hazards associated with the use and handling of payloads containing these hazards. For identification purposes, the various hazardous materials and systems have been grouped into several general categories of potential hazards, such as cryogenic, asphyxiant, etc. However, several of the hazardous materials may fall into two or more of these categories, for example hydrogen can be classified as a cryogenic, an asphyxiant and as a fire hazard. In such cases, the hazardous material has been included under that category where it is most likely to be encountered in a normal processing operation.

Where possible, these discussions have also included recommended decontamination/disposal procedures, safe handling techniques, and detection and/or exposure limits.

The hazard categories and materials included in each are as follows:

- Cryogenics: LH_2, LO_2, LHe, LHeII, LN_2, LNe, and LF_2
- Hypergolics: Hydrazine and its methyl derivatives, nitrogen tetroxide, fluorine, and Inhibited Red Fuming Nitric Acid.
- Toxic/Asphyxiant: Ammonia; gaseous argon, helium, neon, krypton, xenon, nitrogen; Freon 113 and related chlorofluoro compounds; mercury; and silicate esters (coolant fluid).

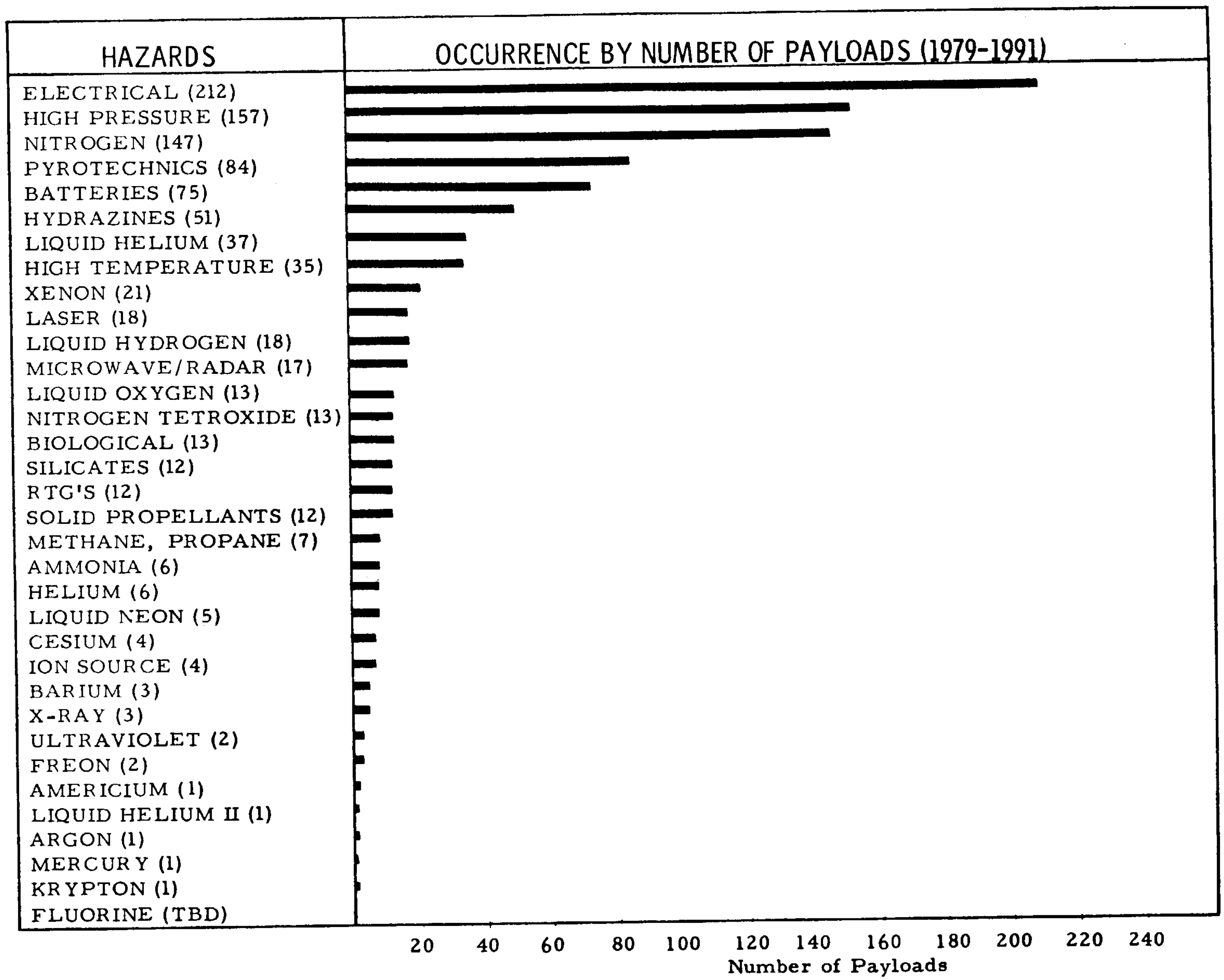


FIGURE 4. HAZARD OCCURRENCE IN PAYLOADS

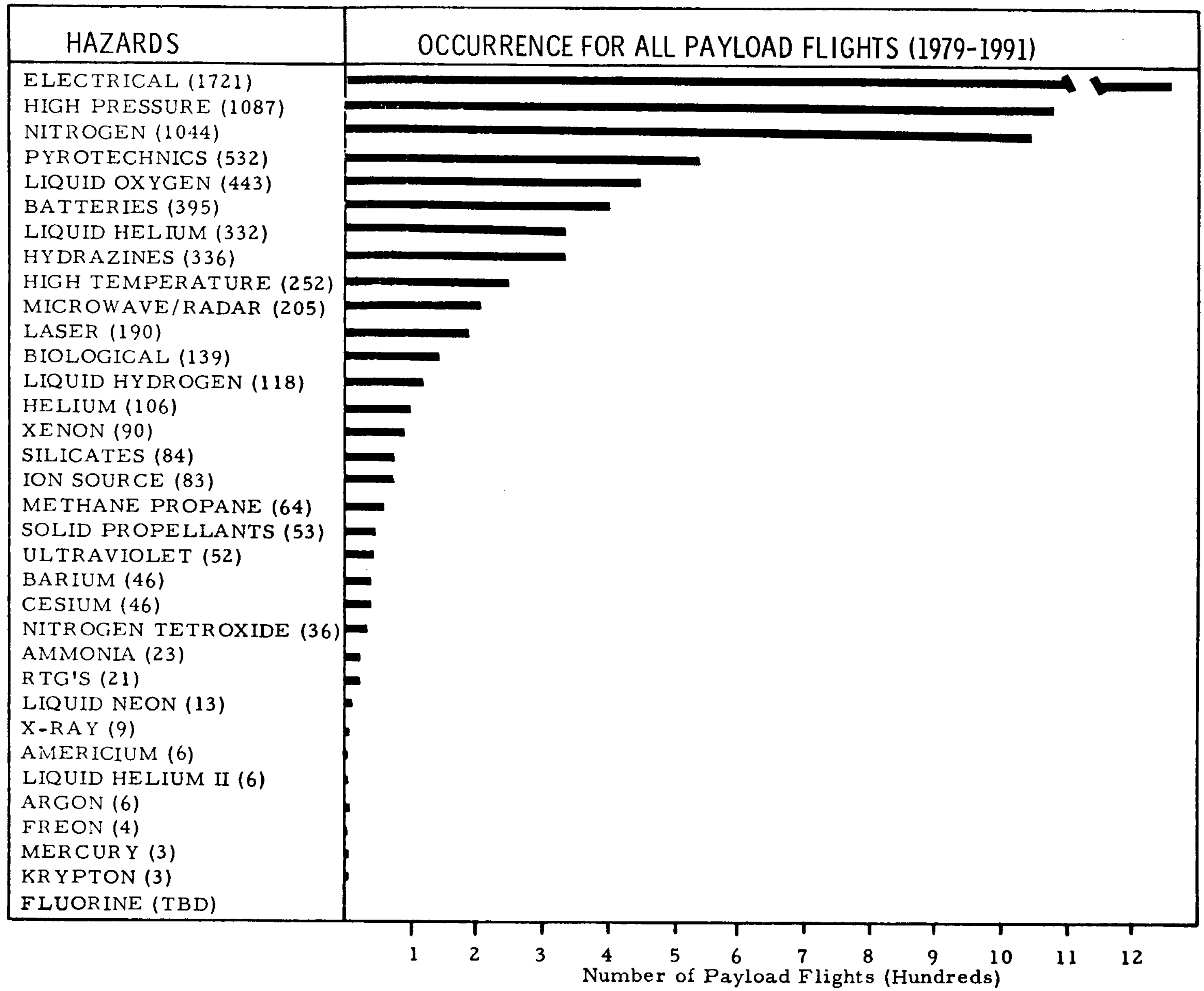


FIGURE 5. HAZARD OCCURRENCE FOR ALL PAYLOAD FLIGHTS (1979-1991)

- Radiological: Radiation including ionizing, ultraviolet, and microwave; radio frequency hazards, and laser hazards.

- Microbiological

- Fire/explosives; Solid Propellants; pyrotechnics; batteries; methane and homologous hydrocarbons; and flammable metals such as rubidium, cesium, and lithium hydride.

2.3 ASSESSMENT TECHNIQUE

The assessment of payload hazards to determine a "hazard potential" provided a relative ranking of payloads. This assessment of payload hazards was performed on a Payload Characteristics and Hazards Assessment Form shown in Figure 6.

The following data were recorded on the Payload Characteristics and Hazards Assessment Form for each of the potentially hazardous Shuttle payloads. These data sheets are included in Appendix B.

- Payload Designation - the appropriate payload code from the SSPD or payload description document.

- Number of Launches - the planned Shuttle flights for the applicable payload.

- Scientific Discipline - the appropriate scientific discipline for the payload (i.e. ASTRONOMY, EARTH OBSERVATIONS, AND PLANETARY).

- Total Payload Hazard Potential - the sum of the hazard potentials for the payload hazards.

- Hazard Source - the hazard material of system hazard category i.e., cryogenic, high pressure, and hypergolic. This hazard category/source was determined from the types of hazardous materials found on the payload.

- Hazardous Material - the hazardous materials and quantities for each payload hazard.

- System/Function - data regarding the payload system containing the hazardous material and the function to be performed by the hazardous system.

PAYLOAD CHARACTERISTICS AND HAZARDS ASSESSMENT

PAYLOAD DESIGNATION ____________

NUMBER OF LAUNCHES ______ SCIENTIFIC DISCIPLINE ____________ TOTAL PAYLOAD HAZARD POTENTIAL ⇨ [ ]

HAZARD SOURCE	HAZARDOUS MATERIAL	SYSTEM/FUNCTION	HAZARD EFFECTS AND INTERACTIONS SUMMARY	A SEVERITY FACTOR 16 4 1 0	B MULTIPLIER FACTOR 100 10 5 1	HAZARD POTENTIAL PRODUCT A x B

FIGURE 6. PAYLOAD CHARACTERISTICS AND HAZARDS ASSESSMENT DATA SHEET

- Hazard Effects and Interactions Summary - the effects of an undesired event or accident and the impact of occurrence of the hazardous condition for each hazard source. Possible interaction effects resulting from different combinations of hazardous systems and materials.

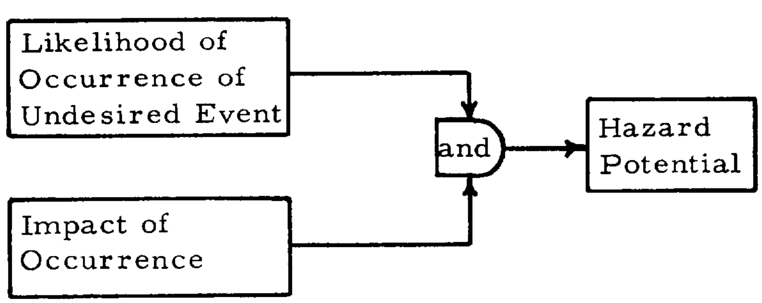
- Severity Factor - weighted severity factors were determined based on degree of loss resulting from a hazardous condition.

- Multiplier Factor - weighted multiplier factors based on the likelihood of an unplanned event being high, medium, low, or negligible.

- Hazard Potential - the number of each hazard source was determined as a product of the severity and multiplier factors.

- Total Payload Hazard Potential - the sum of the individual hazard potentials.

To rank payloads according to their inherent potentiality to cause, to precipitate, or in any other manner to be a prime initiator for undesired and unplanned events or accidents, it was essential to define a method by which total payload hazard potential could be analyzed and and assessed. The term "hazard potential" was defined to provide a relative ranking technique as follows:



Therefore hazard potential, as used in this study, is a function of the likelihood of occurrence of an undesired event and of the impact of occurrence. It is expressed by the following relationship:

Hazard Potential = Weighted Likelihood x Weighted Severity.

In assessing a hazardous payload, a numerical hazard potential was derived for each hazard identified, and these individual hazard potentials were summed to arrive at a total hazard potential for each payload.

The likelihood of occurrence of a potential hazard state becoming a kinetic state (i. e., undesired event) should be a probabilistic measure. However, since this type of data does not exist, the approach used in this study is based on intuitive engineering judgment developed through analyses of similar programs and studies. No attempt was made to estimate probabilities of occurrence but rather to determine a weighted multiplier factor based on the likelihood of occurrence of an event being high, medium, low, or negligible. The assignment of weighting factors to payload hazards was based on past experience with similar systems, familarity of KSC processing of a particular hazardous system, and the state of the art of the hazardous system. Each likelihood statement was given a quantitative value (i. e., weighted multiplier factor). These numbers provide some measure of likelihood but were chosen arbitrarily. The weighting factors used in this study were exponential to provide a spread of values in the hazard potentials. The scheme is as shown below:

Likelihood Statement	Weighted Multiplier Factors
High	100
Medium	10
Low	5
Negligible	1

Impact of hazard, designated as weighted severity, has been defined in terms of four categories of loss statements, each with an exponential weighting factor as follows:

Loss Statement	Effect	Weighted Severity Factors
Catastrophic	Personnel fatality or destruction of loss of major facility or system	16
Critical	Serious personnel injury or major damage to facility or system	4
Marginal	Minor personnel injury or minor damage to facility or system	1
Negligible	Inconvenience or nuisance	0

The loss statements and effects (impacts) were defined in accordance with MIL-STD-882 by modifications that reflect the operations encountered in payload processing and handling operations. Once the method had been established by which all payloads were to be assessed, weighted multiplier and severity factors were derived for each hazard source based upon the severity of the particular hazard. This hazard potential technique is shown in Figure 7.

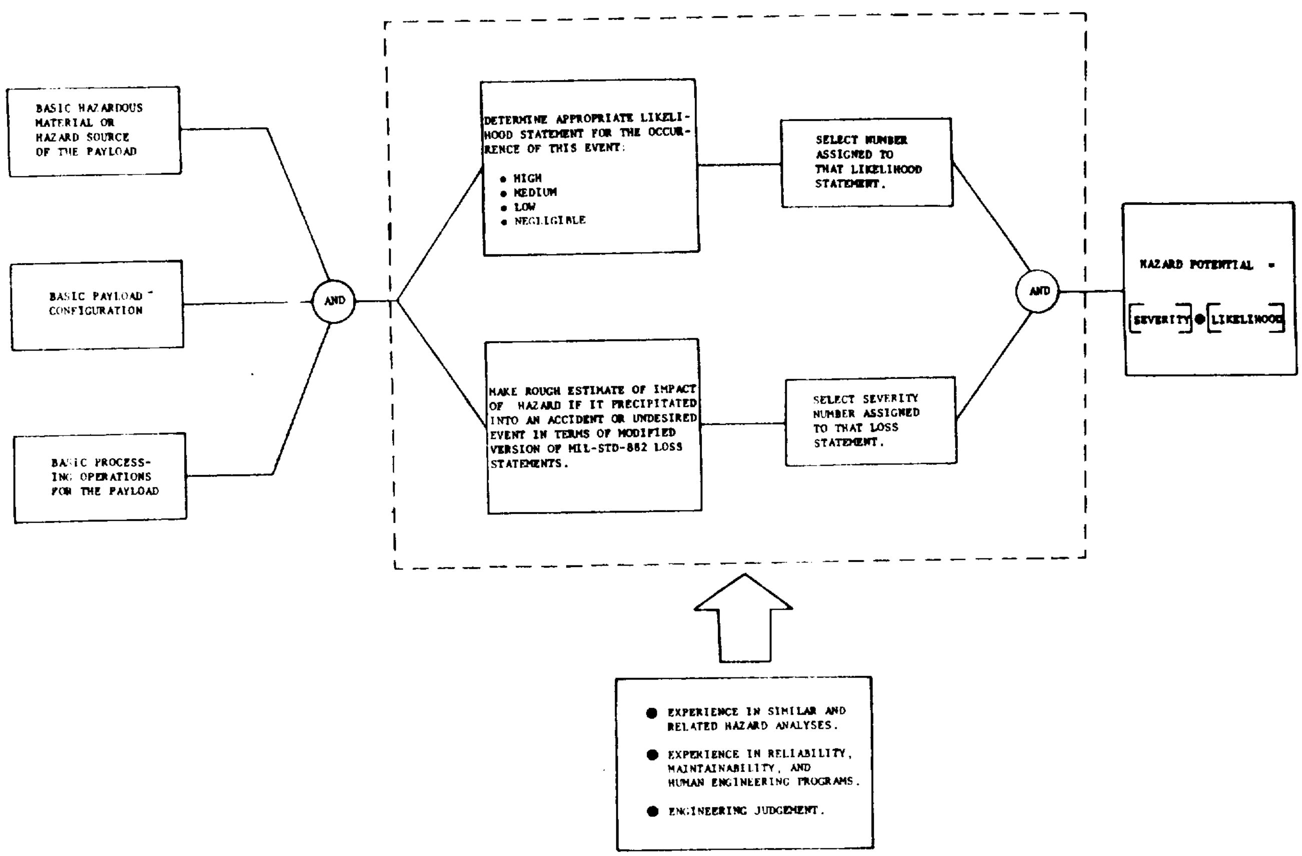


FIGURE 7. HAZARD POTENTIAL TECHNIQUE

3.0 SELECTION OF CARGOES

The selection of representative cargoes for the processing task consisted of assembling a number of tentative candidate cargoes and passing each one through a series of screening operations.

3.1 TENTATIVE CARGO COMBINATIONS

Teledyne Brown Engineering's (TBE) payload specialists hypothetically mated multiple payloads into tentative Shuttle cargoes based on the guidelines established in the payload mission model, the Shuttle mission model, and the Shuttle traffic model. The development of these cargoes was aided by an analysis of the Payload Characteristics and Hazard Assessment forms derived in the initial phase of this task. The combinations of payloads that make up a hypothetical cargo are practically infinite. The combinations were limited by the fact that considerable judgment was exercised to minimize the duplication of like type cargoes. Essentially, initial screening was taking place in the operation. The model documents presented cargoes by discipline categories and not specific payloads as defined in the SSPD. It was, therefore, mandatory that TBE perform the ensuing analysis task.

3.2 SELECTION OF CARGOES

Each of the tentative cargo combinations was subjected to two major screening activities: compatibility testing and cargo selection rationale application. Compatibility tests were devised and each cargo combination was examined and tested as shown in Figure 8. Each of the tentative cargoes was analyzed to ensure that its physical characteristics of size and weight did not exceed the capabilities of the Orbiter. If these limitations were exceeded, the tentative cargo was rejected. Each cargo that did not exceed the physical limitations was then tested for orbital and mission compatibility.

A tentative cargo that passed the compatibility tests was labeled a "Feasible Candidate Cargo" and became eligible for the next screening operation where a cargo selection rationale was applied.

To reduce the number of cargoes to a representative grouping, a method was developed to establish priorities. Each feasible candidate cargo was ranked by combining its hazard potentials and hazardous

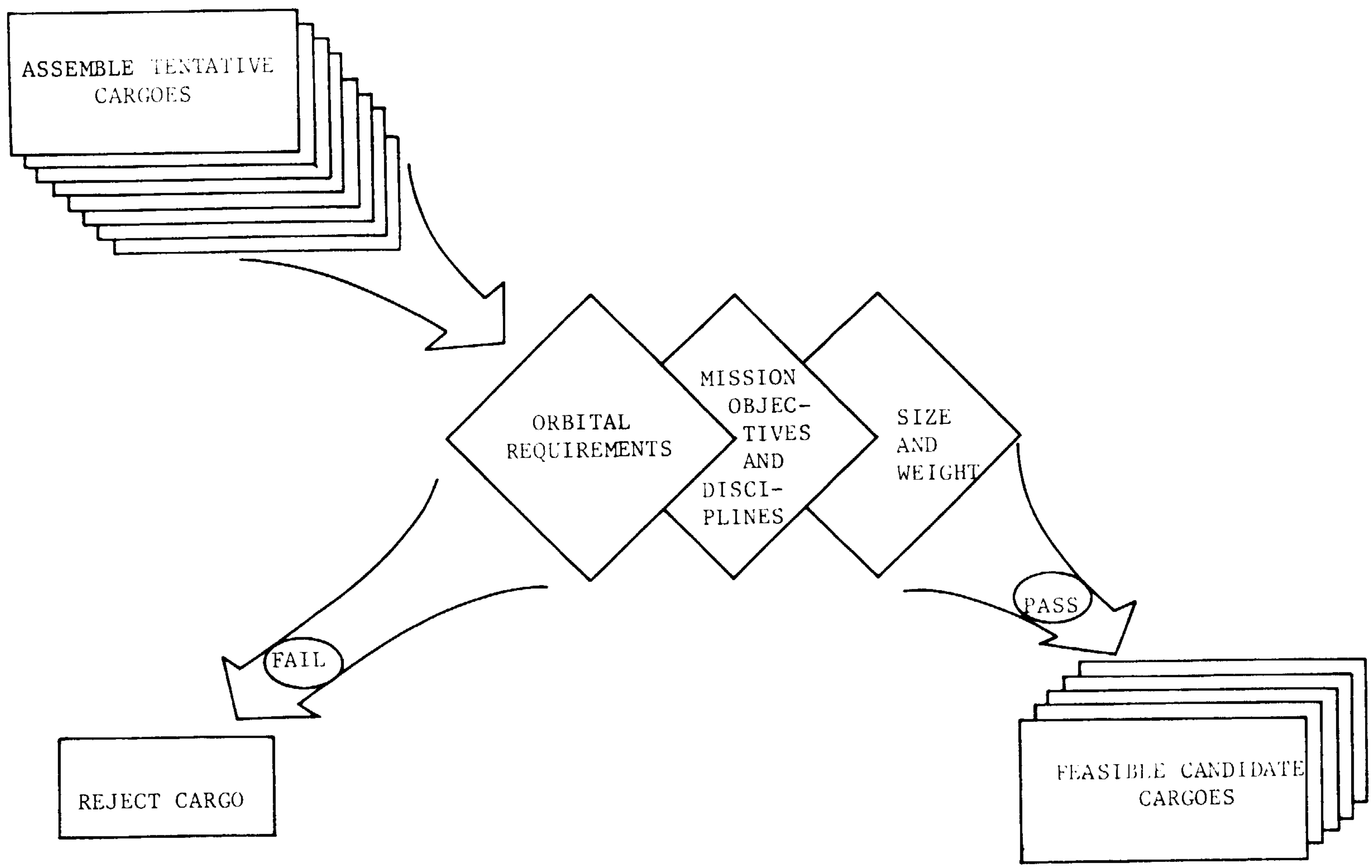


FIGURE 8. COMPATIBILITY TESTING FOR TENTATIVE CARGOES

materials coverage. The cargoes were examined for unique materials or processes and for the estimated number of flights. Figure 9 depicts the logic used in making the selection for the candidate cargo summary. This process yielded 14 cargo packages. Also, four payloads that exhibited unique materials exposure were identified.

The candidate cargoes summary lists the 14 most promising cargo packages for processing analysis. The cargo hazard potentials and hazardous materials are shown in Figure 10.

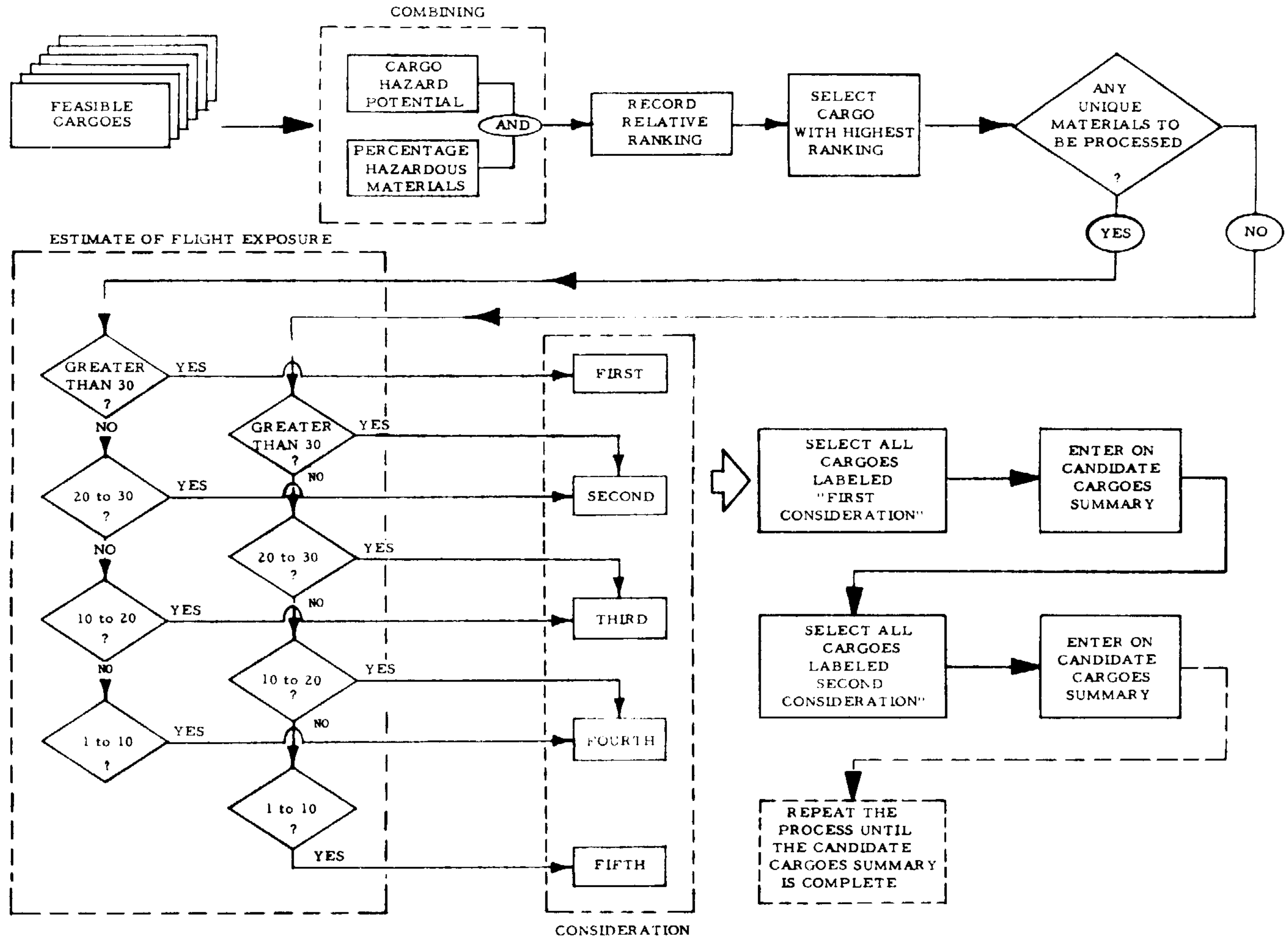


FIGURE 9. CARGO SELECTION RATIONALE

CARGO	CARGO HAZARD POTENTIAL	CANDIDATES	PAYLOAD HAZARD POTENTIAL	CRYOGENICS: LIQUID HYDROGEN	CRYOGENICS: LIQUID OXYGEN	CRYOGENICS: LIQUID HELIUM	CRYOGENICS: LIQUID HELIUM II	CRYOGENICS: LIQUID NITROGEN	CRYOGENICS: LIQUID NEON	HYPERGOL: HYDRAZINE	HYPERGOL: FLUORINE	HYPERGOL: NITROGEN TETROXIDE	TOXIC/ASPHYXIANT: NITROGEN	TOXIC/ASPHYXIANT: AMMONIA	TOXIC/ASPHYXIANT: FREON	TOXIC/ASPHYXIANT: MERCURY	TOXIC/ASPHYXIANT: HELIUM	TOXIC/ASPHYXIANT: XENON	TOXIC/ASPHYXIANT: KRYPTON	TOXIC/ASPHYXIANT: ARGON	TOXIC/ASPHYXIANT: SILICATES/SILICONE	RADIOLOGICAL: PLUTONIUM (RTG'S)	RADIOLOGICAL: BARIUM	RADIOLOGICAL: AMERICIUM	RADIOLOGICAL: X-RAY	RADIOLOGICAL: ULTRAVIOLET	RADIOLOGICAL: MICROWAVE/RADAR	RADIOLOGICAL: LASER	RADIOLOGICAL: ION SOURCE	BIO.: BACTERIA	BIO.: MICROORGANISMS	FIRE/EXPLOSIVE: PYROTECHNICS	FIRE/EXPLOSIVE: SOLID PROPELLANTS	FIRE/EXPLOSIVE: METHANE, PROPANE	FIRE/EXPLOSIVE: BATTERIES	FIRE/EXPLOSIVE: RUBIDIUM	FIRE/EXPLOSIVE: CESIUM	FIRE/EXPLOSIVE: LITHIUM HYDRIDE	HIGH PRESSURE	ELECTRICAL/RFI	HIGH TEMPERATURE
CARGO 1	1160	Storable Propellant Tug	566	●	●					●		●	●				●															●			●				●	●	
		Intelsat (CN-51-A)	297							●			●																			●			●		●		●	●	
		U. S. Domsat "B" (CN-53-A)	297							●																						●			●		●		●	●	
CARGO 2	1069	Storable Propellant IUS	382							●		●	●				●															●			●				●	●	
		F_2PU	436							●	●		●				●															●							●	●	
		Pioneer Jupiter Probe (PL-13-A)	251							●			●									●										●			●				●	●	●
CARGO 3	1281	Storable Propellant Tug	566	●	●					●		●	●				●															●			●				●	●	
		Foreign Synchronous Meteorological Satellite (EO-57-A)	121							●			●																						●				●	●	
		Intelsat (CN-51-A)	297							●			●																			●			●		●		●	●	
		Foreign Communications Satellite (CN-56-A)	297							●			●																			●			●				●	●	
CARGO 4	1240	Cryogenic Propellant Tug	606	●	●					●			●				●															●			●				●	●	
		Solar Electrical Propulsion Stage (SEPS)	433							●			●		●	●			●									●				●			●				●	●	
		Synchronous Earth Observatory Satellite (EO-9A)	201							●			●																			●			●				●	●	
CARGO 5	976	Storable Propellant IUS	382							●		●	●				●															●			●				●	●	
		Intelsat (CN-51-A)	297							●			●																			●			●		●		●	●	
		Foreign Communications Satellite (CN-56-A)	297							●			●																			●			●				●	●	
CARGO 6	1097	Storable Propellant IUS	382							●		●	●				●															●			●				●	●	
		Geosynchronous Operational Meteorological Satellite (EO-58-A)	121							●			●																						●				●	●	
		U. S. Domsat "A" (CN-52-A)	297							●																						●			●		●		●	●	
		Foreign Communications Satellite (CN-56-A)	297							●			●																			●			●				●	●	
CARGO 7	782	Spacelab	72										●		●																								●	●	
		AMPS Physics Sortie Lab Experiment (AP-06-S)	367					●		●			●										●					●				●							●	●	
		Free Flying Teleoperator (LS-04-S)	206							●			●														●								●				●	●	
		Extra Coronal Lyman Alpha Explorer 85 (AS-02-A)	137										●																			●			●				●	●	
CARGO 8	1006	Storable Propellant IUS	382							●		●	●				●															●			●				●	●	
		Foreign Synchronous Meteorological Satellite (EO-57-A)	121							●			●																						●				●	●	
		Disaster Warning Satellite (CN-54-A)	201										●																			●					●		●	●	●
		Traffic Management Satellite (CN-55-A)	302							●			●																			●			●				●	●	●
CARGO 9	844	Solid Propellant IUS	341							●			●																			●	●		●				●	●	
		Upper Atmosphere Explorer (AP-01-A)	286							●			●																			●			●	●			●	●	
		Environmental Monitoring Satellite (EO-56-A)	217							●			●																			●			●				●	●	
CARGO 10	308	Spacelab	72										●		●																								●	●	
		Space Technology Lab	231			●		●																		●	●	●	●	●	●	●								●	●	●
		Integrated Real-Time Contamination Monitor (ST-08-S)	5																																					|●|
CARGO 11	379	Spacelab	72										●		●																								●	●	
		SPA No. 1 Biological (Manned) (SP-01-S)	282	●	●								●								●									●	●				●				●	●	
		ESRO-IR Atmospheric Experiments (NAPE-003)	25			●		●																																●	
CARGO 12	275	Spacelab	72										●		●																								●	●	
		X-Ray Angular Structure (HE-11-S)	37										●					●																					●	●	
		Solar Maximum Mission (SO-03-A)	166										●												●	●						●			●				●	●	
CARGO 13	97	Spacelab	72										●		●																								●	●	
		ESRO-IR Atmospheric Experiments (NAPE-003)	25			●		●																																●	
CARGO 14	165	Mini-Lageos (2) (GP-03-A)	0																																						
		Multi-Discipline Application Sortie Mission B	165										●														●					●								●	

FIGURE 10. CANDIDATE CARGOES SUMMARY

4.0 FINAL CARGO SELECTION

To make a final selection of the most representative hazardous cargoes, a philosophy weighing the highest hazard potential, widest hazardous materials/systems coverage, and highest processing exposure was applied. Also essential to this selection process was the Generalized Processing Scenario developed as a planning instrument for the processing analysis task.

4.1 GENERALIZED PROCESSING SCENARIO

To explore the range of possibilities available to a cargo from a processing point of view, a Generalized Processing Scenario for Payloads (Figure 11) was developed. This is intended to show the available general options that a payload (Tug, Spacelab, Automated Payload) has in processing. The scenario is essentially a high-level processing model for the full scope of alternatives. It shows the basic operational cycle for established types of payloads and how these cycles interrelate to the basic Shuttle flow. It defines the payload disposition at various points in the processing at identified facilities, buildings, and areas. The scenario was devised primarily as a planning instrument for the processing analysis but was used in the final phase of the selection process to ensure the largest scope of processing coverage with a given number of cargoes.

4.2 FINAL SELECTION PHILOSOPHY

The final selection philosophy included consideration of the hazard potential, processing coverage, number of flights, and hazardous materials coverage. The Generalized Processing Scenario, developed as a planning instrument for the processing analysis tasks, was applied in this selection or ranking.

The first cargo is comprised of the Spacelab with an Advanced Technology Laboratory, IRTCM, and a number of experiments of special interest because of new or unique materials/systems (including biological samples).

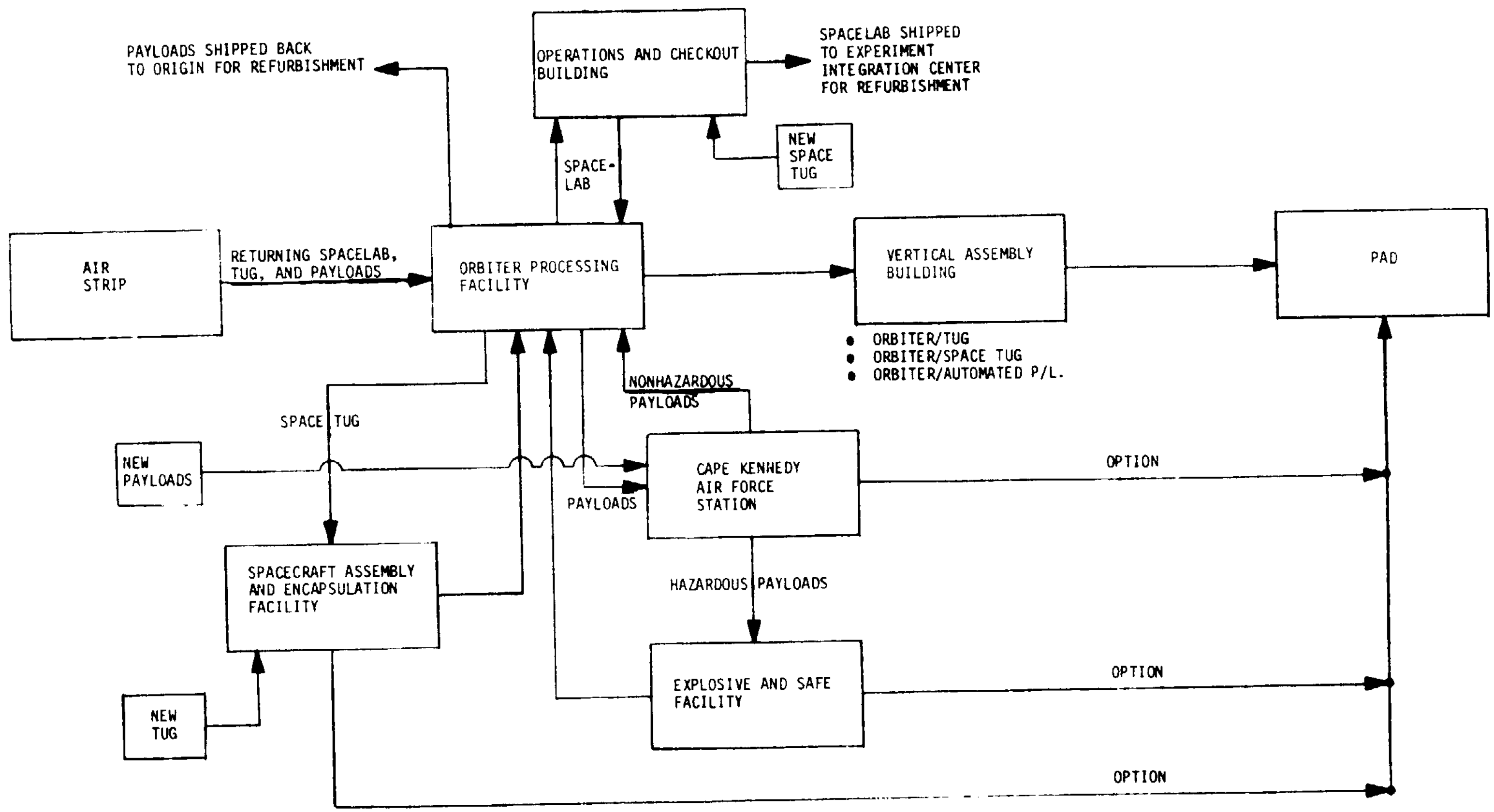


FIGURE 11. GENERALIZED PROCESSING SCENARIO FOR PAYLOADS

The second cargo is a cryogenic fueled tug with a SEPS and a SEOS. The SEPS is a mercury fueled kick stage with a mercury-ion propulsion system. The SEPS payload contains up to 3000 lb of mercury.

The third cargo is the IUS carrying a with a PJP with a Fluorine Propulsion Unit. The Fluorine Propulsion Unit carries from 1500 to 3000 lb of LF_2. The IUS is fueled with hypergolics, the fluorine stage was selected primarily because of the renewed interest in fluorine as a propellant, and the PJP is of major interest because it contains RTG's. This payload carries 3 RTG's, which in addition to their radiation hazard, present a heat dissipation problem of approximately 24,000 Btu/hr.

These three cargoes selected for detailed analysis include the major drivers--fluorine, RTG's mercury, and microbiological. They also represent one or more hazardous systems or materials from each major hazard category.